ately upstream of each of the partial vaporizers was controlled at a temperature 10-20° C. below the boiling point at their respective operating pressures. A conductivity meter in the water supply tank provided continual monitoring of the supply water quality during operation.

[0262] Prior to full startup, system energy losses were measured by operating the system 10° C. below the boiling point and measuring the energy provided to and exiting from the system. The system losses initially ranged from 6 to 10% of the available energy in the system.

[0263] The following table lists the respective temperatures, pressures, and flowrates into and out of each vaporizer.

TABLE 1

Vaporizer conditions

	Low Pressure Vap. #1	Low Pressure Vap. #2
Air inlet temp (C.)	250	372
Air outlet temp (C.)	132	207
Water inlet temp (C.)	86	85.5
Water outlet temp (C.)	104.6	100.3
Air flowrate (SLPM)	150	150
Water flowrate (ml/min)	28.4	20
Water inlet pressure (psig)	2.9	0.7
Water outlet pressure (psig)	2.6	0.1

Low Pressure Partial Vaporizer Number One

Operational Summary:

[0264] The first low-pressure vaporizer completed operation at 9125 hours (~380 days), and demonstrated no signs of degradation during operation. It operated at ~31% vaporization and was fed with ~1 ppm total dissolved solids (TDS) water. The composition of the water was ~0.29 ppm Ca, 40.13 ppm Mg, ~0.19 ppm phosphate, and ~0.15 ppm Cl. The energy provided to the vaporizer via the heated air feed was ~391W. The system heat losses measured prior to full system startup were 39W. The system operated at ~2.9 psig inlet pressure, and ~2.6 psig outlet pressure. The BO number during normal operation was 0.00326, and the SR number was $1.39E10^{-6}$.

[0265] Additionally, the system has endured ~14 cycles, or process upsets, without change in performance which demonstrated the durability of the partial vaporizer. A cycle is defined as a deviation from the expected normal operating condition. The variety of cycles include loss of water flow while the heated air maintained flow, loss of power to the air heater which caused the device to be cooled to room temperature, and loss of power to the entire system. During some cycles, periods of dry-out occurred within the partial vaporizer, however no scale deposition or buildup was observed, as is discussed in the next section in detail. Final data is shown in **FIG. 38**. The long term durability and overall effectiveness of the partial boiling vaporizer is demonstrated in Table 2 and Table 3. Table 2 shows the temperature difference between the water channel wall and the water/steam outlet temperature is small over the duration of the experiment. Table 3 demonstrates the unchanged vaporizer (i.e. heat exchanger) effectiveness before and after two types of cycles. Heat exchanger effectiveness is defined as the actual heat transferred by the air to the water divided by the maximum possible heat that can be transferred by the air.

TABLE 2

Low Pressure Vaporizer number one, Temperature Difference Wall to Water/Steam Outlet

Steam/Water outlet (C.)	Device wall (C.)	Device Wall − Outlet (C.)	Total Time on Stream (hours)
105.6	107.9	2.3	9125

[0266]

TABLE 3

Low Pressure Vaporizer number one, Comparison of Vaporizer Effectiveness before and after cycles

Type of Cycle	Duration (hours)	HEx Effectiveness before cycle	HEx Effectiveness after cycle
Loss of water flow	20	0.73	0.73
Loss of air heater	2.5	0.72	0.72

Post Operation Analysis:

[0267] The device was analyzed for two effects, the first and more important effect was to look for signs of fouling on either the air or water sides, and the second effect was to look for material degradation such as pitting or corrosion.

[0268] The device was cut apart to visually observe no signs fouling or particulate buildup in the microchannels. The device was then cut into eight cubes such that the center channels of the device could also be seen, and again demonstrated no signs of fouling in either the air channels or the water channels. Using SEM, no obvious signs of pitting were observed. The EDS data indicate that there was an oxide scale on the surface that is rich in Fe, and Cr in some cases, likely from the underlying metal. Common hard water scale elements such as Ca and Mg were not present.

Low Pressure Partial Vaporizer Number Two

Operational Summary:

[0269] The second low-pressure vaporizer was operated 2041 hours. It was taken offline to investigate probable fouling. Fouling was suspected due to the decreased steam quality, and increased air outlet temperature (i.e. less heat being transferred to the water side). Data are shown in **FIG. 39**. The vaporizer operated with decreasing steam quality, from ~85% to 50% and was fed with 12-15 ppm TDS water. The actual composition of the water was ~2 ppm Ca, ~0.9 ppm Mg, ~0.27 ppm Sr, ~0.67 ppm Cl, ~1.8 ppm sulfate, and ~7 ppm bicarbonate. The system operated at ~0.7 psig inlet pressure, and ~0.1 psig outlet pressure. The BO number during normal operation was 0.0068, and the SR number was $4.30E10^{-6}$.

[0270] This system also demonstrated durability as it endured ~9 cycles without change in performance. The upsets are the same as those listed in the low pressure